INDOOR AIR QUALITY ASSESSMENT

Burgess Elementary School
45 Burgess School Road
Sturbridge, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program

September 2004

Background/Introduction

At the request of Brent Coon, Principal, and Rick Weatherbee, Facilities Director for the Tantasqua Regional School District, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Burgess Elementary School (BES), 45 Burgess School Road, Sturbridge, Massachusetts. The request was prompted by general indoor air quality and health concerns occupants believed to be associated with the building.

On June 4, 2004 a visit to conduct an indoor air quality assessment was made to this school by Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Mr. Holmes was accompanied by Mr. Weatherbee and, for portions of the assessment, Mr. Coon.

The BES is a one-story, brick building constructed in 1948. Additions were built in 1954, 1960 and in 1973. The school contains general classrooms, science classrooms, music rooms, media center, gymnasium, cafeteria, art rooms and office space. The former south cafeteria is used as classroom space. The 1973 portion of the building has an open floor configuration, where five-foot high dividers partition classrooms into "pods".

School officials reported that no major renovations have been made to the building. However, school officials reported that they were expecting a report from a comprehensive feasibility study conducted prior to the BEHA assessment. The feasibility study assessed building-wide material/structural needs (e.g., building envelope, electrical/wiring, ventilation).

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID).

Results

The school houses approximately 835 students in pre-kindergarten through sixth grade and a staff of approximately 125. The tests were taken during normal operations at the school. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in eighteen of thirty areas, indicating inadequate ventilation in a number of areas. It is important to note that several classrooms had open windows and/or exterior doors, which can greatly reduce carbon dioxide levels. When exterior doors and windows are closed, carbon dioxide levels would be expected to be higher. Each wing has a different type of heating, ventilating and air conditioning (HVAC) equipment, which was reportedly installed during the wing construction. Older equipment can be difficult to maintain/operate due to age and availability of parts. The following describes the ventilation systems in each wing.

1948 Wing

Fresh air in classrooms in the 1948 wing is mechanically supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (Picture 1) and return air through an air intake located at the base of each unit. Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit (Figure 1). Univents were found deactivated in a number of classrooms. Obstructions to airflow, such as items on top of univents and/or tables and desks in front of univent returns, were also seen in a number of classrooms (Picture 2). To function as designed, univents must be activated and remain free of obstructions.

Exhaust ventilation in the 1948 wing is provided by gravity vents, which consist of ungrated floor level "cubby" holes. As outside air is introduced into classrooms via the univents or open windows, the room becomes pressurized forcing air into the cubbies and out the exhaust vents. These vents were being used for storage throughout the wing, thereby obstructing airflow (Picture 3). Without sufficient supply and exhaust ventilation, environmental pollutants can build up and lead to indoor air quality complaints.

1954 Wing

Fresh air in the 1954 wing is also provided by univents. As with the 1948 wing, a number of univents were found deactivated or obstructed, thereby preventing proper airflow and limiting the introduction of fresh air.

Mechanical exhaust ventilation in the 1954 wing classrooms consists of grilles located in the ceilings of coat closets (Picture 4), which are powered by rooftop motors. Air is drawn into the coat closet from the classroom via undercut closet doors (Picture 5). This exhaust system was either not functioning or drawing weakly in several areas surveyed, indicating the motors were deactivated or non-functional. BEHA staff examined exhaust motors on the roof and found several not operating. Mr. Coon reported that several of the exhaust motors were on a work list and scheduled for repair. In addition, the location of these closet vents allows them to be easily blocked by stored materials. As with the univents, in order to function properly, exhaust vents must be activated and remain free of obstructions.

1960 Wing

Mechanical exhaust ventilation in the 1960 wing is also provided by univents. Many units were deactivated or obstructed at the time of the assessment. Exhaust ventilation is provided by grated wall vents (Picture 6), which are powered by rooftop motors. As with other wings, a number of vents were not drawing air or drawing weakly. Some exhaust vents were also obstructed.

1973 Wing

Mechanical ventilation in this wing is provided by rooftop air handling units (AHUs) ducted to ceiling-mounted air diffusers (Picture 7). Return air is ducted back to the AHUs via ceiling or wall mounted return vents. At the time of the assessment, Mr. Coon reported that the AHU for the computer lab and kindergarten classrooms had ceased operating, and a request for proposal (RFP) to replace the AHU had gone out to bid. As a temporary measure, exterior doors had been opened to provide fresh air in these areas.

The south cafeteria is a large room that was sub-divided into separate learning areas. Mechanical ventilation is provided by two AHUs suspended from the ceiling. These AHUs were not operating and appeared to have been deactivated for some time.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical ventilation system, the systems must be balanced subsequent to installation to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see Appendix A.

Temperature measurements ranged from 68^{o} F to 75^{o} F, which were close to the BEHA recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. However, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents, AHUs and exhaust vents inoperable, deactivated and/or obstructed).

The relative humidity measured in the building ranged from 40 to 51 percent, which was within the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Mr. Coon reported that despite roof repairs in several areas, the building continues to have active roof leaks. Water damaged ceiling tiles were observed in a number of areas throughout the building. Water-damaged ceiling tiles can provide a source of mold growth and should be replaced after a water leak is discovered and repaired.

Pooling water was observed around clogged roof drains (Picture 8). The freezing and thawing of water during winter months can lead to roof leaks and subsequent water penetration into the interior of the building. Pooling water can also become stagnant, which can lead to mold and bacterial growth. Such growth and associated odors can also be introduced to the building by rooftop ventilation equipment. In addition, stagnant pools of water can serve as a breeding ground for mosquitoes.

Spaces between the sink countertop and backsplash were noted in several classrooms (Table 1). Improper drainage or sink overflow can lead to water penetration of countertop wood, the cabinet interior and behind cabinets. Like other porous materials, if these materials become wet repeatedly they can provide a medium for mold growth.

Plants were located in front of univent air intakes and/or near univents air diffusers (Pictures 1 and 9). Plants, soil and drip pans can serve as sources of mold growth. Over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants should also be located away from univents and ventilation sources to prevent aerosolization of dirt, pollen or mold.

Shrubbery and other plants were also seen growing in close proximity to exterior walls (Pictures 10 and 11). The growth of roots against the exterior walls can bring moisture in contact with wall brick. Plant roots can eventually penetrate the brick, leading to cracks and/or fissures in the below ground level foundation. Over time, this process can undermine the integrity of the building envelope, providing a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

Other Concerns

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants; however, the pollutant produced is dependent on the material combusted. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address airborne pollutants and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient-Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter. As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detectable or ND (Table 1). Carbon monoxide levels measured in the school were also ND.

Occupants reported periodic complaints of vehicle exhaust entrainment from school busses. During certain wind and weather conditions, vehicle exhaust can potentially be drawn, or entrained, through the univent fresh air intakes. This may, in turn, provide opportunities for exposure to compounds such as carbon monoxide. M.G.L. chapter 90 section 16A prohibits the unnecessary operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes (MGL, 1986).

Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 microgram per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particle levels be maintained below 65 $\mu g/m^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 23 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors ranged from 7 to 26 $\mu g/m^3$, which were below outdoor levels in all but one area. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulates during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC measurements throughout the building were also ND.

Please note, TVOC air measurements reported are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Several other conditions that can affect indoor air quality were observed during the assessment. Of note was the amount of materials stored inside classrooms. In some classrooms, items were seen on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. Accumulated dust in the school was also noted on the blades of personal fans (Picture 12) and exhaust vent grills. These items should be periodically cleaned to prevent the rearosolization of dust particles. Accumulated chalk dust was seen in some classrooms. Chalk dust is a fine particulate that can easily become aerosolized. Once aerosolized, chalk dust can become irritating to eyes and the respiratory system.

Occupants reported musty odors in the restrooms near classroom 21. These odors were also detected by BEHA staff. Exhaust vents in these restrooms were not drawing air. In addition, the exhaust vent in one restroom had a grill missing (Picture 13); the vent in the other restroom was sealed. Exhaust ventilation in restrooms is important in removing excess moisture and odors. Although no complaints were reported, the potential of odor entrainment into the school exists. Several dumpsters behind the building were observed in close proximity to univent air intakes (Picture 14).

Several classrooms contained upholstered furniture, large cushions and/or pillows (Picture 15). Upholstered furniture is covered with fabric that comes in contact with human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. In addition, if relative humidity levels increase above 60 percent, dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry 1994). It is also recommended that upholstered furniture present in schools be professionally cleaned on an annual basis. If an excessively dusty environment exists due outdoor conditions or indoor activities (e.g., renovations), cleaning frequency should be increased to every six months (IICR, 2000). Elevated outdoor levels of airborne particulates can result in increased levels of indoor particulates by entering into the building through open windows, doors and filter bypass.

Finally, inactive wasps and birds' nests that reportedly serve as learning props were noted in classrooms. Nests can contain bacteria and may also be a source of allergenic material. Nests should be placed in resealable bags to prevent aerosolization of allergenic material. These items should also be located away from univents fresh air diffusers.

Conclusions/Recommendations

The conditions noted at the BES raise a number of issues. General building conditions, building configuration, the condition/age of HVAC equipment and the limited availability of replacement parts, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons, a two-phase approach is required. The approach consists of **short-term** measures to improve air quality and **long-term** measures that require planning and resources to adequately address overall indoor air quality concerns.

The following **short-term** measures should be considered for implementation:

1. Ensure all operable ventilation systems (supply and exhaust) throughout the building (e.g., classrooms, cafeteria, former south cafeteria) are operating continuously during periods of school occupancy. Continue with plans to replace AHU over computer room.
2. Inspect exhaust motors and belts for proper function. Continue to make repairs and replace parts as necessary.
3. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
4. Consult a ventilation engineer concerning re-balancing of the ventilation systems. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).
5. Repair and/or replace thermostats as necessary to maintain control of comfort.

6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (e.g., throat and sinus irritations).
7. Repair roof leaks. Replace any remaining water-stained ceiling tiles. Examine the areas above and around these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
8. Remove accumulated plant debris from roof. Inspect roof drains regularly for proper drainage.
9. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary. Keep plants away from the air stream of univents.
10. Remove foliage to a minimum of five feet away from the foundation. Trim trees in rear of building that overhang the roof. Ensure univent air intakes on the exterior of the building are free of obstruction.
11. Seal areas around sinks to prevent water-damage to the interior of cabinets and adjacent wallboard. Inspect wallboard for water-damage and mold/mildew growth, repair/replace as necessary. Disinfect areas of microbial growth with an appropriate antimicrobial as needed. Consider replacing with one-piece, molded countertops.

12. Work with bus/transportation contractor to prevent excessive idling of vehicles. If necessary, consider posting signs instructing vehicles to shut engines off after five minutes as required by Massachusetts General Laws 90:16A.
13. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
14. Clean accumulated dust from exhaust vents and blades of personal fans.
15. Clean chalkboard/dry erase marker trays regularly to prevent the build-up of excessive chalk dust and particulate.
16. Consider relocating dumpsters away from air intakes to prevent the entrainment of odors.
17. Store nests in resealable bags to prevent aerosolization of irritants.
18. Clean upholstered furniture on the schedule recommended in this report. If not possible/practical, remove upholstered furniture from classrooms.
19. Consider adopting, the US EPA (2000b) document, Tools for Schools, in order to provide self assessment and maintain a good indoor air quality environment at your building. The document can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.
20. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://www.state.ma.us/dph/beha/iaq/iaqhoFtme.htm.

The comprehensive feasibility study will more than likely describe many of the building's needs and provide recommendations for improvement. The following **long-term** recommendations are made as a complement to the feasibility study.

1. Contact an HVAC engineering firm for a full evaluation of the ventilation system and its control system (e.g., pneumatic controls, air intake louvers, thermostats). This measure is strongly recommended, given the age, physical deterioration and availability of parts for the HVAC system
2. Continue with plans for roof replacement in areas of chronic leakage.

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Picture 1

Univent Fresh Air Intake, Note Plant Growth in Front of Vent

Picture 2

Classroom Univent Obstructed by Various Items, Univent is Late 1940s model

Picture 3

Items Stored in Exhaust Vent "Cubby", 1954 Wing

Picture 4

Exhaust Vents in Ceilings of Coat Closets, 1960 Wing

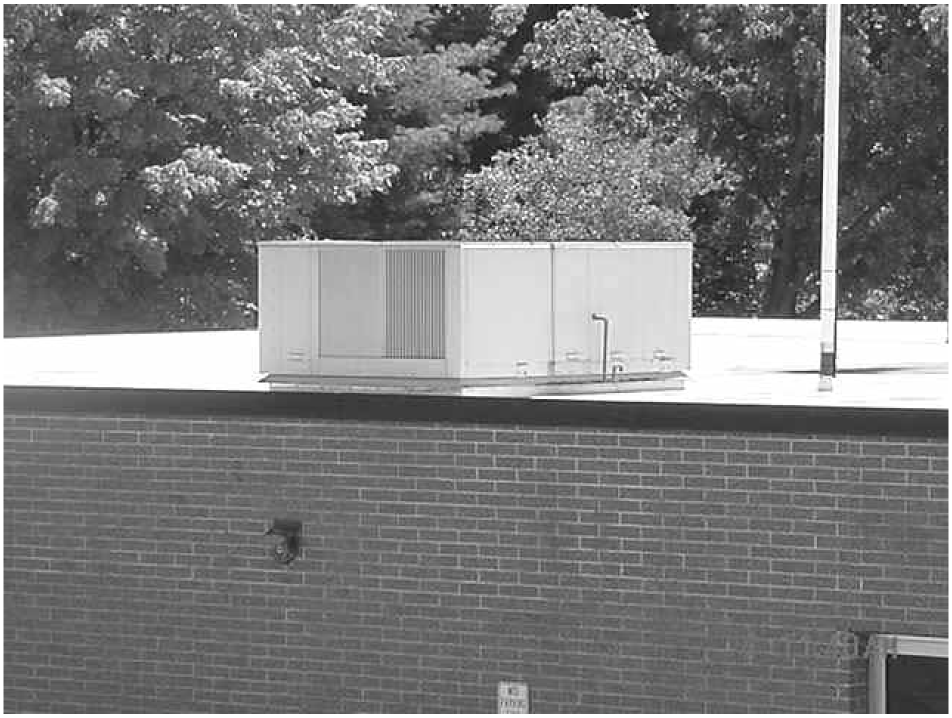
Picture 5

Full-View of Coat Closet, 1960 Wing

Picture 6

Exhaust Vent 1960 Wing

Picture 7



Rooftop AHU, 1973 Wing

Picture 8

Clogged Roof Drain

Picture 9

Plants on Univent Air Diffuser

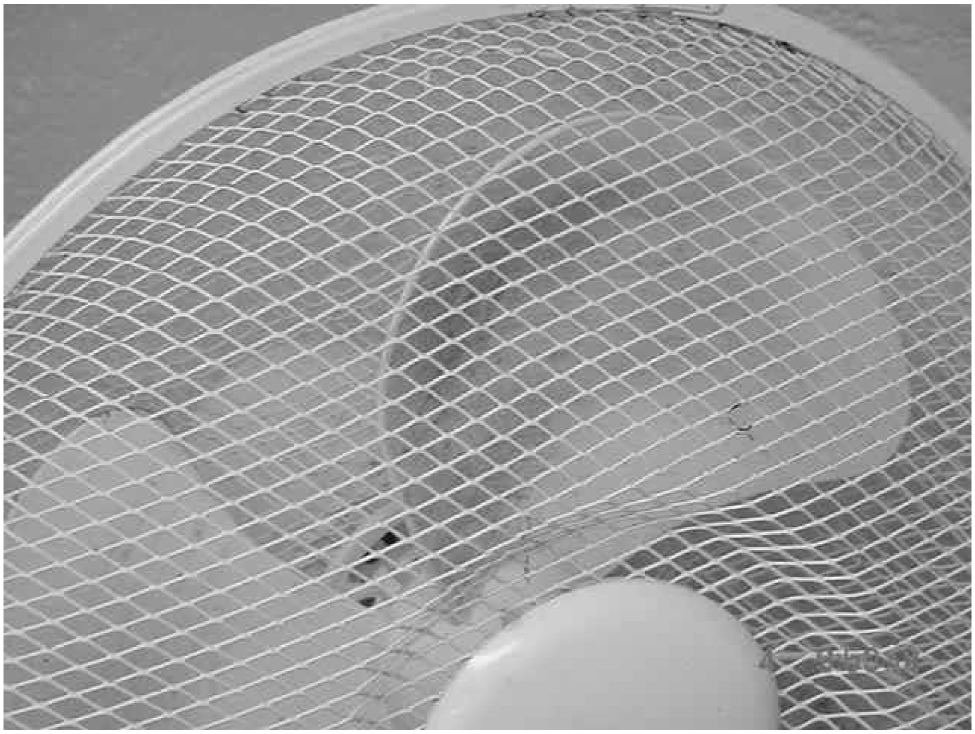
Picture 10

Plant/Tree Growth Against Exterior Brickwork

Picture 11

Tree Growth Against/Over Roof of School

Picture 12



Accumulated Dust on Fan Blades

Picture 13

Missing Exhaust Vent Grill in Restroom, Near Classroom 21

Picture 14

Dumpsters in Close Proximity to Air Intakes

Picture 15

Cushions and Pillows on Floor of Classroom

Sturbridge Burgess Elementary School **Indoor Air Results**

45 Burgess School Road, Sturbridge MA **June 4, 2004**

Table 1

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background (outdoors)	65	42	372	ND	ND	23			-	-	Mostly sunny, North winds 10 mph
P-12	71	51	1379	ND	ND	19	21	Y	Y	Y	Aqua., plants Univent supply blocked by furniture. Exhaust blocked by clutter
P-11	72	48	1399	ND	ND	16	25	Y	Y	Y	Univent supply blocked by clutter. Exhaust blocked by boxes, clutter
P-10	78	44	1521	ND	ND	17	19	Y	Y	Y	Plants. Univent supply blocked by furniture, clutter. Exhaust blocked by clutter
P-9	72	48	1502	ND	ND	16	23	Y	Y	Y	CD. Univent supply blocked by furniture. Exhaust blocked by furniture, clutter
P-8	73	48	1915	ND	ND	21	21	Y	Y	Y	CD, DEM, clutter, nests, plants. Closet exhaust
P-7	71	44	1029	ND	ND	13	9	Y	Y	Y	DEM

ppm = parts per million parts of air
µg/m3 = microgram per cubic meter
WD = water damage
AD = air deodorizer
AP = air purifier

CD = chalk dust
DEM = dry erase marker
DO = door open
ND = non detect
PC = photocopier

PF = personal fan
TB = tennis balls
UF = upholstered furniture
UV = univent
CT = ceiling tile
MT/AT = missing/ajar tile

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Sturbridge Burgess Elementary School

45 Burgess School Road, Sturbridge MA

Table 1

Indoor Air Results

June 4, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
P-5	72	45	1080	ND	ND	26	0	Y	Y	Y	DEM, PF. Univent supply off, blocked by clutter. Closet exhaust blocked by clutter.
M-6	71	44	797	ND	ND	15	18	N	Y	Y	Items on CT. Ceiling supply.
V-5	72	43	730	ND	ND	8	13	N	Y	Y	Items on CT. Ceiling supply
S-1	72	45	646	ND	ND	12	17	N	Y	Y	Nests
M-3	71	44	766	ND	ND	8	17	N	Y	Y	Items on CT. Ceiling supply
S-2	70	48	827	ND	ND	122	17		Y	Y	Ceiling supply off. Exhaust off
S-3	72	48	845	ND	ND	18	18		Y	Y	Ceiling supply off. Exhaust off

ppm = parts per million parts of air
µg/m3 = microgram per cubic meter
WD = water damage
AD = air deodorizer
AP = air purifier

CD = chalk dust
DEM = dry erase marker
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Cafeteria	74	46	1328	ND	ND	16	~260		Y	Y	Ceiling supply and ceiling exhaust
V-6	71	43	623	ND	ND	72	1		Y	Y	DEM, cleaners. AHU Down. OCL w Lunch;; ceiling supply off, exhaust off
U3-U4	72	44	723	ND	ND	10	0		Y	Y	Items on CT. Ceiling supply off, exhaust off
Project SIPP	70	45	542	ND	ND	7	5		Y	Y	Inter-room door open, AHU Down, Ceiling supply off, Exhaust off
Computer Room	71	44	495	ND	ND	8	3		Y	Y	Exterior door open, AHY down, ~30 computers. Ceiling supply off, exhaust off
South Cafe	72	46	864	ND	ND	15	0		Y	Y	2 AHU off, ceiling supply off, wall exhaust off
SPED SO. Cafe	72	47	839	ND	ND	21	0	Y			PF, Dusty fan, WD carpet-scheduled to be removed

ppm = parts per million parts of air
µg/m3 = microgram per cubic meter
WD = water damage
AD = air deodorizer
AP = air purifier

CD = chalk dust
DEM = dry erase marker
DO = door open
ND = non detect
PC = photocopier

PF = personal fan
TB = tennis balls
UF = upholstered furniture
UV = univent
CT = ceiling tile
MT/AT = missing/ajar tile

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Sturbridge Burgess Elementary School **Indoor Air Results**

45 Burgess School Road, Sturbridge MA **Table 1** **June 4, 2004**

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
14	72	47	1247	ND	ND	9	19		Y	Y	PF, clutter, hallway door open, univent supply blocked by clutter. Wall exhaust blocked by clutter.
15	73	48	878	ND	ND	25	4	Y	Y	Y	DEM, clutter, rattling noise UV, wall exhaust
16	75	49	1124	ND	ND	21	15	Y	Y	Y	DEM, clutter. UV deactivated due to noise. Univent supply off, blocked by clutter, furniture; closet exhaust blocked by clutter.
17	74	46	601	ND	ND	10	17	Y	Y	Y	DEM, PF, clutter, plants. Supply off, blocked by furniture. Closet exhaust blocked by clutter
18	74	48	1254	ND	ND	15	20	Y	Y	Y	PF, clutter; univent supply off; closet exhaust blocked by boxes.
19	71	40	704	ND	ND	11	14	Y	Y	Y	Clutter, plants, pillows/cushions. Univent supply off, closet exhaust.

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Sturbridge Burgess Elementary School

45 Burgess School Road, Sturbridge MA

Table 1

Indoor Air Results

June 4, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
20	73	46	849	ND	ND	13	17	Y	Y	Y	PF, clutter; univent supply blocked by clutter, wall exhaust blocked by furniture
21	71	47	803	ND	ND	18	16	Y	Y	Y	DEM; UV-deactivated, Hallway door open; rest rooms musty odors, no local ex-working, vents abandoned
23	70	46	615	ND	ND	13	1	Y	Y	Y	PF; periodic bus fumes complaints; univent supply.
Pre-school	68	42	420	ND	ND	22	5		Y	Y	Exterior door open; ceiling supply off, exhaust off

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